

The Controversy of Myopia as a Risk Factor for Glaucoma: a Mathematical Approach

G. Guidoboni(1,2), S. Cassani(1), L. Carichino(1), Y. Arieli (2), B.A. Siesky(2), A. Harris (2)

(1) Dept of Mathematical Sciences, IUPUI; (2) Dept of Ophthalmology, IUSM

Indiana University – Purdue University Indianapolis

Abstract

Purpose: to quantify how individual variations in anatomical parameters often associated with myopia (e.g. longer ocular axial length (OAL), reduced scleral thickness (ST), lamina cribrosa diameter (LCD) and thickness (LCT)) affect retinal blood flow (RBF) and its sensitivity to ocular perfusion pressure (OPP).

Methods: A mathematical model is used to calculate RBF through central retinal artery (CRA), arterioles, capillaries, venules, and central retinal vein (CRV). The flow is time-dependent, driven by systemic pressure and regulated by variable resistances to account for nonlinear effects due to (1) autoregulation (AR), and (2) lamina cribrosa effect on CRA and CRV. The latter is a nonlinear function of intraocular pressure (IOP), cerebrospinal fluid pressure (CSF) and OAL, ST, LCD, and LCT. RBF is computed as the solution of a system of five non-linear ordinary differential equations. The system is solved for different OPP values, obtained by varying independently IOP and mean arterial pressure (MAP), with and without AR.

Results: Four representative eyes are compared: Eye 1 (OAL=24mm, ST=1mm, LCD=3mm, LCT=0.4mm), Eye 2 (OAL=28mm, ST=1mm, LCD=3mm, LCT=0.4mm), Eye 3 (OAL=24mm, ST=0.7mm, LCD=2mm, LCT=0.2mm), Eye 4 (OAL=28mm, ST=0.7mm, LCD=2mm, LCT=0.2mm). The model predicts that the cardiac cycle RBF average (RBFav) for eyes with smaller LCD and LCT is notably less than in normal eyes when IOP is elevated and without AR (c). Without AR and reduced MAP, the four eyes show similar RBFav reductions (d). With AR, anatomical changes do not induce notable changes in RBFav, (a) and (b).

Conclusions: Reduced LCD and LCT, often associated with myopia, seem to affect RBFav more than elevated OAL. RBFav reductions magnify when AR is impaired, and this might reduce IOP safe levels for eyes with reduced LCD and LCT. These findings suggest that a combination of anatomical and vascular factors might cause certain myopic eyes to be at higher risk for glaucomatous damage than others.